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EFFECT OF FURROW LENGTH AND METHODS OF APPLYING IRRIGATION ON COTTON YIELD AND WATER USE EFFICIENCY

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ABSTRACT

A field experiment was conducted in 1997 growing season, at El-Karda Water Requirements Research Station, Kafr El-Sheikh Governorate, to evaluate the furrow lengths and method of applying irrigation on cotton seed yield and water use efficiency. Five treatments were arranged in split-plot design. Three of them for furrow lengths which were 40, 60 and 80 meters and the others for methods of applying irrigation water (with siphon-without siphon).

The obtained results showed that the cotton seed yield increased with decreasing furrow length and using siphon tube-in the applied irrigation water. There is no significant difference in values of water consumptive use among treatments. The treatment of 40 meters furrow length with using siphon tube recorded the highest values of irrigation application efficiency, crop water use efficiency and field water use efficiency . Data revealed also that the use of siphon tubes method for irrigation obtained the advantage of controlling water given to the field.

INTRODUCTION

Irrigation is generally defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth. Efficient use of irrigation water is an obligation of each user. However, efficiency of use will vary from locality to another. In areas where water is scarce and costly, available water should be used carefully.

Israelsen & Hansen (1962) stated that irrigation water is applied to land by three general method; namely, (a) Surface by flooding (b) subsurface or with furrow; in which the surface is wetted little if only, and (c) Sprinkling in which the soil surface is wetted much as it is by rainfall. Criddle *et al.* (1956) showed that the maximum allowable length of run is the longest distance in which the maximum allowable furrow stream can affect nearly uniform distribution of water in the soil. He added that the higher efficiencies might be obtained if the fields are shorter than the maximum allowable. But, if the fields are only slightly longer than the maximum allowable, a lower irrigation efficiency might be preferable to cut the furrow length in two. Salam *et al.* (1972) estimated the maximum allowable length of furrow that does not cause any excessive erosion using siphon tube method under different soils from the following equation:

$$L = \sqrt{\frac{4 \times 7.6 \times 10^{-4} \times W^{10/3}}{cd \times TT \times d^{2} \sqrt{2gh} \times 2340}} \times \frac{1}{K}$$

Where:
L = Maximum allowable length of the furrow.
W= Furrow spacing.
Cd= Discharge coefficient of siphon tube .
d = Inside diameter of siphon tube.
h = Head of siphon tube.
TT= Total time required to irrigation.
g = Gravity acceleration.
K = Permeability Coefficient.

Salam *et al.* (1973) stated that adequate control and management of irrigation water require methods to evaluate irrigation practices from the time at which water leaves the point of diversion until it is utilized by the plants. The best irrigation device is that which minimizes the waste of water as much as possible . The use of siphon tubes method for irrigation has the advantage of controlling water given to the field. El – Mowelhi *et al.* (1990) and Saied (1992) pointed out that the water requirement of cotton was from 3200m3 to 3900m3, the water consumptive use were from 52.89 cm to 58.42 cm and the water application efficiencies was from 63 to 74% according to the land leveling method and irrigation water discharge. *Eid & Hosny (1995)* pointed out that optimum water requirement for cotton will range between 94.5 and 115.5 cm in Egypt, depending on regional climate.

The aim of this work is to study the effect of furrow length and methods of applying irrigation water on cotton seed yield, water consumptive use and water use efficiency.

MATERIALS AND METHODS

This study was conducted at El-Karada Farm (Kafer El-Sheikh) governorate in the summer season of 1997, to study the effect of furrow length and methods of field irrigation on cotton seed yield, its water consumptive use and water use efficiency.

Treatments:
A : Furrow Lengths:
A1 : Furrow length of 40m,
A2 : Furrow length of 60 m and,
A3 : Furrow length of 80 m.

B: Methods of field irrigation
B1: Using siphon tubes ;
B2: Without siphon tubes.

A split plot design with four replicates was used. The main plots were subjected to the furrow length treatments and the Sub-plots were to the methods of field irrigation. Cotton (Giza 86) was planted on March 30 and harvested on October 20, 1997 and all the experimental treatments received

the same agricultural practices as usual in this area. The analysis of the field experiment soil was done according to Jackson, (1958) and Black (1965) which indicated that the soil texture was clayey, ECe 2.18 dSm-1 in saturated paste extract, pH 8.1 in 1:2.5 soil water suspension. The hydraulic characteristics, Field capacity 38.67% , willting point 21.01% and bulk density 1.15 g/cm^3(average of 0–6 0cm).

Water relations :The amount of applied irrigation water was measured by a wair using this equation :

$$Q = CLH^{3/2}$$ ……(Masoud, 1967)

Where

Q = The discharge in cubic meters per second

C = An empirical coefficient that must be determined from discharge measurements.

L = The length of the crest in meters.

H = The head in meters.

The irrigation water was applied to the furrows by siphon (Inside diameter was 4cm). Water consumptive use was calculated according to the following equation:

$$CU = \sum_{n=1}^{i=1} \frac{\theta_2 - \theta_1}{100} \times Bd \times \frac{60}{100} \times 4200$$

……. (Israelsen and Hansen, 1962)

Where

CU = Water consumptive use, m^3/Fed.,

N = Number of irrigations,

$\theta 2$ = Soil moisture content % after irrigation,

$\theta 1$ = Soil moisture content% before irrigation and

Bd = Soil bulk density (g/cm^3).

Irrigation efficiency :

Irrigation application efficiency (Ea):

Values of irrigation application efficiency (Ea) for each treatment was obtained by dividing the irrigation water stored on the applied irrigation water (Downy, 1970);

$$Ea = \frac{Ws \times 100}{Wd}$$

Where :

Ea = Water application efficiency.

Ws= Water stored.

Wd= Water delivered to the field plot.

Irrigation distribution efficiency:

It is express the uniformity of the distribution of irrigation water through the root zone.

$$Ed = 100 \left(1 - \frac{Y}{D}\right) \quad \text{… (Michael,1978).}$$

Where
Ed = Water distribution efficiency ,%.
Y = Average numerical absolute deviation in depth of water stored .
D = Average depth of water stored during the irrigation.

3-Crop water use and utilization efficiency

Crop water use efficiency is the weight of marketable crops produced Per the volume unit of water consumed by plants or the evapotranspiration quantity (Abd El -Rasool *et al.,* 1971). The utilization efficiency is the weight of marketable crops produced per the volume unit of applied irrigation water expressed as cubic meters of water (Michael, 1978).

RESULTS AND DISCUSSION

1-Effect of furrow length and method of applying irrigation water on cotton seed yield:-

Means of cotton seed yield in Kentar per feddan as influenced by the furrow length and method of applying irrigation water are presented in Table (1). Data revealed that yield of cotton seed was not affected significantly by furrow length treatments. The highest values was obtained from treatment A_3 (5.95 Kentar/Fed). followed by treatment A2 (5.88 Kentar/Fed.), while the minimum cotton seed yield was obtained from treatment A_1. Also it was noticed that the method of applying irrigation water significantly affected cotton seed yield. Treatment B_2 recorded the highest value 6.3(Kentar/Fed.)While treatment B2 recorded the lowest values (5.44 Kentar/Fed). The interaction effect of Ax.B. was not significant.

Table (1): The average values of cotton seed yield (kentar/fed.) as affected by furrow length and method field irrigation in 1997 season.

Treatments	Cotton seed yield (Kentar/fed.)
Furrow length ,m	
40	6.01
60	5.88
80	5.73
Mean.	5.87
F. test.	NS
L.S.D. 5%	-
L.S.D. 1%	-
Method of Field Irrigation	
Used siphon tube	6.30
Without siphon tube	5.44
Mean	5.87
F. test	**
L.S.D 5%	0.14
L.S.D 1%	0.33
Interaction A x B	NS

**** and NS means significant at 1% and not significant, respectively .**

2- Water consumptive use

The seasonal water consumptive use by cotton plants as influenced by Furrow length and method of applied irrigation water is shown in Table (2).

The furrow length 80 m (A 3) recorded the highest values of cotton consumptive use (63.82cm), while the lowest values was obtained from furrow length 40 m treatment (63.34cm). On the other hand, the methods of applied irrigation water without using siphon tube consumed more water in comparison with using siphon tube

Table (2): Seasonal water consumptive use for cotton plants as affected by different treatments in 1997 season.

Treatments		Water Consumptive use	
Furrow Length ,m	**Method of Applied irrigation**	**(m^3/Fed.)**	**(cm)**
40	With Siphon	2660.19	63,34
	Without siphon	2670.19	63.58
60	With Siphon	2665.82	63.47
	Without siphon	2679.68	63.80
80	With Siphon	2669.10	63.55
	Without siphon	2680.71	63.82

3- Total amount of irrigation water

The amounts of applied irrigation water delivered to different treatments are given in Table (3).

It is clear from data obtained that the water requirements for cotton plants range between 3500 and 3638 m^3/Feddan. The highest value was recorded from treatment A3, while the lowest value is obtained from A1.On the other side, the siphon tube can saved more water than without using siphon. The average value of saved water was 43.33 m^3/Fed.

Table (3): Number of irrigations and amounts of irrigation water delivered to the different treatments.

No. of Irrigations	Length of Furrow					
	40 m		60m		80 m	
	With Siphon, m^3 / fed	Without Siphon, m^3 / fed.	With Siphon, m^3 / fed.	Without Siphon, m^3 /fed.	With Siphon, m^3 / fed.	Without Siphon, m^3 / fed.
Planting	670	680	700	700	710	720
1	305	315	301	310	355	365
2	404	406	305	412	445	450
3	430	435	450	452	465	471
4	449	450	440	460	375	377
5	419	425	460	449	435	440
6	413	414	421	409	420	425
7	410	414	385	400	372	389
Total	3500	3539	3562	3592	3577	3638
Water saving m^3 / Fed	39		30		61	

4- Soil moisture extraction pattern :

Data of soil moisture extraction percentage in the upper 60cm of soil are presented in Table (4).

Data revealed that the most of the water consumed by cotton roots is removed from the soil surface layer. The highest Percentage of the moisture uptake by cotton plant roots is occurred in the surface 15cm depth of the soil profile, it ranges between 43.49 and 45.06%. Less water is extracted from the successive depths. It can be concluded that about 69.14% of the stored water which used by cotton plants is obtained from the surface soil layer (30cm) and about 30.86% from the sub-surface layer (30-60cm). These conclusions are similar to those obtained by Karev (1974), Taylor and Klipper (1974), and Saied (1992).They found that 70-90% of cotton roots are found in the surface 40-50cm of soil profile.

Table (4): Mean values of soil moisture extracted (percentage) by cotton plants from different layers as affected by different treatments in 1997 season.

Treatments		Soil depth (cm)			
Furrow Length, m	Methods of Applied irrigation	0-15	15-30	30-45	45-60
40	With Siphon	45.06	25.34	16.89	12.71
	Without siphon	43.89	25.73	17.50	12.89
60	With Siphon	43.87	25.27	18.36	12.52
	Without siphon	43.96	24.86	18.07	13.12
80	With Siphon	44.55	24.52	17.82	13.11
	Without siphon	43.49	24.32	18.52	13.68

5- Irrigation application efficiency:

Values of irrigation application efficiency are shown in Table (5).

The average values of water application efficiency were estimated and found to be 69.16, 68.28 and 67.8%for A_1, A_2, and A_3 treatments, respectively while for B1 and B2 were found to be 68.66 and 68.19%, respectively.

Table (5): Values of water stored, applied irrigation water and irrigation application efficiency as affected by the different treatments in 1997 season.

Treatments		Water Stored (m^3/ Fed.)	Applied Irrigation Water(m^3/ Fed.)	Irrigation Application Efficiency(%)
Furrow length (m)	Method of Applied irrigation			
40	With Siphon	2429.10	3500	69.40
	Without siphon	2439.19	3539	68.92
60	With Siphon	2434.82	3562	68.36
	Without siphon	2449.68	3592	68.20
80	With Siphon	2440.14	3577	68.22
	Without siphon	2452.71	3637	67.44

6- Water use efficiently and utilization efficiency:

Values of water use and utilization efficiency as influenced by the different treatments are shown in Table (6). Generally it is noticed that the highest values of water use and utilization efficiency are accompanied with the highest values of cotton seed yield. The water utilization efficiency takes the same trend of crop water use efficiency, which the combination of A_1B_1 gave almost the highest value 0.39 and 0.30 Kg / m^3 for crop water use and utilization efficiency, respectively. Similar trend was reported by El-Mowelhi *et al.* (1994).

7-Water distribution efficiency:

The obtained data of the water distribution efficiency were calculated and are presented also in Table (6).

Data showed that the water distribution efficiency increased as the furrow length decreased. On the other hand, the water distribution efficiency increased by using siphon tube method. The mean values of water distribution efficiency for the different furrow lengths were 95.75, 92.81 and 89.4% for furrow lengths of 40, 60. 80 meters long, respectively. Generally the present study indicated that the furrow length of 40 m and using siphon tube were found to be the best combination to obtain maximum cotton seed yield and also to save more water for other purposes.

Table (6): Crop water use efficiency, field water use efficiency and water distribution efficiency for cotton as affected by furrow length and method of applied irrigation water in 1997 Season.

Treatments		Crop water Use Efficiency(Kg/m^3)	Field Water use Efficiency(Kg/m^3)	Water Distribution Efficiency(%)
Furrow length(m)	Method of Applied irrigation			
40	With Siphon	0.39	0.30	97.35
	Without siphon	0.32	0.24	94.14
60	With Siphon	0.36	0.27	93.85
	Without siphon	0.33	0.25	91.77
80	With Siphon	0.36	0.27	89.85
	Without siphon	0.31	0.23	88.95

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تأثير طول الخط وطرق الرى الحقلى على محصول القطن وكفاءة استخدام المياه

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أجريت هذا البحث من خلال تجربة حقلية فى الموسم الصيفى لعام 1997م بمحطة تجارب المقننات المائية بالقرضا -محافظة كفرالشيخ وذلك لتقييم طول الخط وطريقة إضافة ماء الري و تأثير ذلك علي انتاجية محصول القطن و كفاءة استخدام المحصول للماء.

تم ذلك بدراسة ثلاث معاملات لطول الخط وهى :- طول خط 40م ، طول خط 60م ، طول خط 80م ،وكذلك دراسة معاملتين لطرق إضافة ماء الرى إحداهما باستخدام طريقة السيفون والأخرى بدونة. وقد لوحظ من النتائج أن إنتاجية المحصول تزداد بنقص طول الخط باستخدام طريقة السيفون فى إضافة الماء للتربة. لا يوجد فروق معنوية فى قيم إستهلاك الماء . وقد أعطت المعاملة طول خط 40م وباستخدام طريقة السيفون أعلى قيم فى كفاءة إضافة الماء للتربة وكفاءة استخدام نباتات القطن للماء. كذلك أوضحت النتائج أن استخدام طريقة السيفون فى إضافة ماء الرى تكون أفضل من حيث التحكم فى كمية الماء المضاف للحقل.